Teaching Introductory Database Course Online

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ABSTRACT

This article describes the conversion of our introductory database course from in-classroom teaching to online one. The conversion has been done according to the methodology developed at the very beginning of the planning phase for online teaching. The teaching method has been described as well as the hardware and software used for lectures and lab-work. The paper shows a way how lectures for the first database course can be taught. Additionally, several different possibilities for students to do lab-work online and explain their pros and cons have been discussed. This approach has the advantage that students can make their own choice between different database systems, when exercising.

General Terms

Database systems

Keywords

Online teaching, Database systems, SQL

1. INTRODUCTION

During the winter semester of 2021, all lectures at the Rosenheim Technical University of Applied Sciences were held in an online-only format. This applied also to the introductory course “Database Systems”, which has been read by the instructor during that term. In this paper, the evolution of in-classroom teaching lecture to online teaching one. The lecture was given for undergraduate students from a computer science-related program.

The move from in-classroom teaching to fully digital one meant that all aspects of the course have to be questioned and most of them to be changed. On the other hand, throwing the existing material away (for the lectures and lab-work), was no option due to available preparation time. Therefore, the fundamental idea was to keep the content of the lectures and lab-work mainly as it was.

In relation to the course, the changes have been described and the reason for them have been explained. For each decision, a short discussion of the alternatives and the benefits and disadvantages have been given. Note that we do not assert that our model is the best model for teaching an introductory database course online, because there does not exist the best model. The goal has been to find the online teaching style that suits to us, using the software licensed by our university.

1.1 Related Work

The work concerning online teaching of database systems and the related language (SQL) can be divided in two independent areas. The first one describes articles dedicated solely to the experience in relation to teaching a database course online. To the second area belong articles which describe different web-based interactive tools for learning and practicing SQL. The most important representatives of both areas will be described below.

Dittrich et al [1] give in an experience report on teaching the undergraduate database lecture online. They describe their teaching methods as well the tools used for online teaching. In contrast to this article, the emphasis of the article written by Grust [2] is to describe the conversion of two database courses from their in-classroom teaching into an all-digital remote format delivered by YouTube.

There are several articles introducing interactive tools for learning SQL. SQL Tutor [3] is an intelligent teaching system employed in teaching SQL to university students. The system is customized to the specific needs of each student. It employs constraints in the feedback process to deliver the semantic and syntactic descriptions of the errors. SQLator [4] is an online learning workbench. Its engine evaluates whether a proposed solution in SQL is correct. It also has several databases and allows learners to choose which of the databases they want to study.

1.2 Roadmap

This paper is structured as follows. The teaching methodology has been introduced in Section 2. First, the teaching method has been discussed and, after that, the changes in the teaching material due to transition from in-classroom teaching to the online one are explained. In Section 3, the impact of certain hardware parts on our online lectures as well as all kinds of software used for the course have been described. Section 4 is dedicated to the detailed presentation of lectures as well as lab-work. Additionally, the extensive evaluation list, used at the end of the course to provide students' feedback, is presented in this section. Finally, the important issues have been summarized and an outlook for changes in the future work in has been given in Section 5.

2. METHODOLOGY

2.1 Teaching Students Online

The most important issue concerning online teaching is to consider the ways how to teach, and not which tools to use. For this reason, an overview, how online teaching can be done, is given first.

In relation to teaching methods, there are two opposed ways and one in between:

- Live teaching
- Flipped teaching
- Hybrid solutions of online teaching

Live teaching means that the lecturer runs his/her lecture live, over the Internet. The main characteristic of live teaching is that teacher and students interact in real-time. In other words, the content of the lecture is streamed to the students, which are not at the same place as the lecturer. (The students can be located at some private places, as well as in the traditional lecture halls.)

Flipped teaching is a teaching form, where students receive material ahead of time, for studying at home. The actual class, called “flipped classroom” is used by students to watch or hear lessons at their home and/or do a lab-work during the class time.

The main issue concerning the decision which approach to take, is the degree of communication between the lecturer on one side and the students on the other. The flipped teaching has benefits for students as well as lectures. The main advantage for the students during the flipped teaching is that this teaching form shifts the focus from the teacher's needs to the student's ones. One of main advantages of the flipped teaching for lecturers is that the lecture can be reused as many times as he/she wants, until the content becomes outdated.

The main disadvantage of flipped teaching for students is that during the self-study time, questions to the lecturer in real time are not possible, and the students are left alone. At the same time, this is the main advantage of live teaching, because the students can interact with the lecturer directly. (Hybrid solutions of online teaching involve all possible combinations of live and flipped teaching.)

Knowing all these issues we had to decide, how to teach and how to perform lab-work. These are two independent tasks, while the requirements for both decisions are significantly different. The decision concerning lab-work was easy: From our point of view, the only way to exercise with students in an introductory database course is using live teaching, because it is necessary that teacher and students interact in real-time with each other. The reason for this decision is manifold:

- a) Generally, the lab-work for any introductory computer course should be “face-to-face”, while the students do not have any previous knowledge of the topic. Hence, the direct communication between teacher and students is essential for the success of the lab-work.
- b) At our university, all undergraduate students from computer science-related programs learn one or more programming languages before attending the database course. In relation to teaching SQL, this experience is not helpful. Learning SQL is significantly different than learning programming languages, such as C or Python, because SQL is declarative and set-oriented language. (On the other hand, programming languages are procedural and record-oriented.) Therefore, learning SQL is a new paradigm for these students and has to be taught differently.
- c) The use of RDBMSs, such as PostgreSQL, Oracle or MS SQL Server significantly differs from teaching other courses in computer science, while new issues (such as indices, performance tuning etc.) are generally not known to the students.

The decision concerning lecturing was not so easy to make, because all teaching methods described above were possible, and all of them have their benefits and disadvantages. Practical reasons have been crucial to decide to use flipped teaching, as will be explained in Section 4.2.

2.2 Teaching Material

Since 1991, the introductory database course has been held for students in the department of computer science. During all these years, the course has been modified frequently. The reason for modification was that other university departments introduced the same course, but the requirements of different departments varied, as well as the number of semester hours. Therefore, a lot of material has been available in form of slides for topics, such as relational database systems, data

warehousing, NoSQL systems etc. The part of the existing material has been used for lectures in this course, while the existing exercises used in the previous years, have been slightly modified for online lab-work (see Section 4.2).

3. TECHNOLOGY

3.1 Hardware

In terms of hardware, the Acer V 15 laptop (18” monitor), with Intel Core i5-6200U and CPU with 2.40 GHz clock speed, as well as with 16 GB RAM is used. Although the laptop used for the course belongs to the middle-range ones (in relation to CPU, processor etc.), there were no performance problems during online lectures. For lab-work hours, an additional 24” monitor has been used.

There are two other important issues concerning hardware. One is good illumination. The face camera benefits significantly from good lightning. Therefore, during the teaching hours, we took care that illumination of our working place at home was always good.

Even more important than good illumination is the use of a professional microphone. Our experience showed that in relation to audio quality, the built-in microphones are no match to the professional ones. For this reason, it is strongly recommended to use a professional microphone for online courses. (The microphone could be either placed close to the screen or installed on an extensible arm.)

Students used their own hardware for lectures, while in relation to lab-work they had two possibilities: either to use (virtually) the hardware located in the computer center of the University or their own laptops. (This issue will be discussed in detail in Section 4.2.)

3.2 Internet Connection

An unexpected issue occurred during the first weeks of teaching in relation to the internet connection. At the beginning, wireless connection to the Internet has been used, and it showed that this connection was not stable enough for online teaching. After switching to LAN connection, the problems disappeared. For this reason, the use of wired connection instead of wi-fi is recommended.

3.3 Video Communication Tool

The direct communication with students in real time is, from our point of view, the best way to do lab-work. For this reason, a video communication tool was required for exercising. The only such tool, licensed by the University was Zoom.

The learning curve for Zoom was rather steep, and after a week of practicing the lecturer could use the most important functions in relation to doing exercises. Zoom offers the same functions, which the lecturer has already used doing lab-work in classroom.

When communicating with students, the use of the “chat mode first, audio mode optionally” option is recommended. This option means that the default communication channel between students and the lecturer is chat. In other words, students are not allowed to use audio mode when interacting with the lecturer. When the question sent by a student is relevant for all students, the lecturer switched the audio mode for the student from chat to audio. (Otherwise, the answer was sent per chat to that student.)

The advantage of this option is that the lecturer can decide whether the asked question is important to the student only, or for all of them. In the latter case, the microphone of the student asking the question was activated.

3.4 Content Management System

The default content management system at the university is Moodle. The lecturer has not used Moodle at all before the beginning of the online course, and it had some negative impacts. Moodle is a very complex system, and the learning curve was slow-angled. Also, the University was not prepared for such extensive use of the system. Hence, at the beginning, the support was very limited.

The other significant disadvantage is that Moodle design is rather confusing. It is very hard to find some functions. For instance, the function “Add a new directory” is often used, but it is almost impossible to find it without help of Google or a friendly hint of a colleague. Another weak point of the tool is the hard way to perform students’ evaluation.

The lesson learned is that in case of Moodle (or any other corresponding content management tool), lecturers should start early to practice with the management system, so that they are ready to use it, when it is necessary.

4. REALIZATION OF LECTURES AND LAB-WORK

4.1 Lectures

The lectures have been taught using Powerpoint Video recording system and the output files have been stored under Moodle. The decision to use Moodle instead of YouTube, as a storage platform, has been based upon the following issues:

- a) The Powerpoint slides existed already and could be used for online teaching without significant changes. The foundation of the introductory database course has always been the extensive set of slides, designed to have a significant amount of illustrations and tables. To create new videos for YouTube requires generally a lot of time, which was not available because of the tight schedule.
- b) Powerpoint offers better features for granting group access to slides than YouTube. YouTube supports three modes of private settings: public videos, private videos and unlisted videos. The main idea, concerning the visibility of slides, has been to make them visible only to the students attending the course. None of the YouTube private settings allow this. (Unlisted videos can be viewed only by the users having the link to it, but it is not the same as building the group of users, which have the read access for the videos.)
- c) Security of user’s data is not given when watching YouTube videos. YouTube is an online video platform owned by Google. Google is known as the company with best tools to mine personal data of users.

4.2 Lab-work

The main topic in an introductory database course are relational database systems. The important characteristic of these systems, which influences the lab-work, is their client/server (C/S) architecture. In other words, the question, where to install the front-end and where the back-end of the database system chosen for the lab-work is the main issue, before the lab-work starts. For our lab-work, three alternatives have been offered:

- a) The installation of a front-end on the student’s computer and the use of the already installed back-end of MS SQL Server 2017 on the university site.
- b) The installation of front-end and back-end of any RDBMS on the student’s computer.
(In our case, this option was limited to three specified RDBMSs.)

- c) The usage of the already installed front-end and back-end of SQL Server 2017 on the university site.

4.2.1 Front-end on the student’s computer and back-end on the university site

As already stated, the back-end of SQL Server 2017 has been installed at the university site several weeks before the lab-work started. For this option, the students had to install one of Microsoft’s front-ends for SQL Server, depending on their operating system. 90% of students, who chose this alternative, installed the standard front-end for the Windows operating system called SQL Server Management Studio and 10% Azure Data Studio (the front-end for non-Windows operating systems, such as Linux and MacOS).

During the lab-work hours, the students had to start the VPN client on their computers before the connection to the back-end could be established. After that, they used the personal credentials to connect to the system and the corresponding database. (For each student, a login and the corresponding sample database have been created several weeks before the begin of the semester.)

It became apparent that this approach has several advantages and one disadvantage. The main advantage of the approach is its simplicity: the only task for students is to install the front-end.

The second advantage is its reliability, because the students do not have to worry about administration tasks, such as creating databases as well as ensuring that their data are up-to-date.

The only minor disadvantage has been the necessity to install one of the SQL Server’s front-end. As students’ evaluation showed, this task did not make any problems, because the installation of any SQL Server front-end is generally user-friendly.

4.2.2 Front-end and back-end on the student’s site

Almost all vendors of commercial database systems offer a free edition of their RDBMS. This so-called Express Edition (XE) does not have the complete functionality of the “standard edition” in relation to the maximum database size and the supported features, but it is the best tool for lab-work in an introductory database course.

This option allowed students to use *any* existing RDBMS for their lab-work. (In practice, the choice has been limited to three systems: MS SQL Server, Oracle and PostgreSQL.) This option has several benefits and several disadvantages. First, the whole installation process remains in the hands of the student. This can be disadvantageous, when student’s computer skills, are limited.

One important advantage of this option is that students are not limited to do lab-work solely with MS SQL Server. (In the winter of 2021, 22 students attended the course. Two students installed and worked with PostgreSQL, the other students used MS SQL Server.)

There is also one disadvantage: The whole system (front-end and back-end) has to be configured and maintained. These tasks take a lot of time, and can be strenuous, if the student does not have any previous knowledge concerning database systems.

Generally, this solution is probably the best one from the student’s point of view, because of variety of different DBMSs, which can be used.

On the other hand, the lecturer needs a significant amount of time to “streamline” the lab-work so, that all examples conform to all supported RDBMSs. This can be done when standardized syntax of SQL statements is used for all lab-work hours.

4.2.3 Front-end and back-end on the university site

This option means that a student can “reserve” a computer located in one of lab-work rooms of the computer center for a certain time and use it from her/his domicile. This remote access requires VPN connection, plus, in case of Windows operating system, the remote desktop protocol (RDP) connection. (RDP is a proprietary protocol developed by Microsoft which provides a user with a graphical interface to connect to another computer over a network connection.)

Before using this option, each student had to install the RDP client and start the client before the remote access can be established. After that, a graphical presentation of computer labs, with all existing computers is given, and the student chooses one of them.

If the chosen computer is not in use already, the desktop of that computer appears on the screen, and the student can click the icon of one of SQL Server front-ends. Using their credentials, students can do their lab-work.

This approach has one advantage and several disadvantages. The advantage is that students do not have to do any installations concerning the DBMS. In other words, front-end and back-end of the database system exist and can be used immediately.

On the other hand, there are several disadvantages which make the use of this approach very difficult. The most important is the complex procedure to “reserve” one of the computers in the computer center. First, several connections (VPN and RDP) have to be made, before the student can reserve one of existing computers for herself/himself.

Second, selecting one of listed computers does not mean that it is available and can be used. In the attempt to reserve a computer fails, the selection process has to be repeated until a free computer can be reserved. Also, the computer center of the University limits the usage time to the selected computer, so the longer usage of the computers in the computer center is not always possible. (In the winter semester of 2021, several students in the course tested this option, but no one used it for lab-work.)

4.3 Students' Evaluation

The evaluation has two parts, one in relation to the course in general, and the second one in relation to online teaching. In this article only the latter will be presented. (Note, that each item of the students' evaluation has the additional option, which allows students to write their own remarks to the topic of that item.) The list of evaluation items is as follows:

- 1) How do you rate your private computer gadgets for online teaching?
 - a) Tablet / Laptop / Notebook / iPad
 - b) External Webcam
 - c) Built in Webcam
 - d) Printer/Scanner
 - e) Internet stability
- 2) How do you rate the technology components for online teaching?
 - a) Access and downloading from the content management system?
 - b) Access to the video communication platform?
- 3) Was it possible to clarify your online questions with the lecturer?
- 4) Concerning the video communication platform: How do you rate the “chat mode first, audio mode optionally” option for communication between lecturers and students?

- 5) The following issues in relation to online teaching are important for me:
 - a) Working in the groups, i.e. discussions in break-out sessions;
 - b) Consolidation of the self-prepared topics with the lecturer;
 - c) Writing comments on the screen by the lecturer;
- 6) How did you experience the online teaching during the semester? (In other words, is online teaching more strenuous at the beginning or at the end of the semester?)
- 7) How important for you is that the lecturer turns his/her camera continuously on, during the online lectures?
- 8) How important for you is that all fellow students turn their cameras continuously on, during the online lectures?
- 9) I turn my camera off during the online lectures, while ...
- 10) How often (in average) you do “multitasking” during the online lectures? (“Multitasking” = to chat, reading/writing emails, etc.)
- 11) Grade the course material (videos and online presentations) stored on the content management system.
- 12) How long should online video presentations last? (Specify the time maximum.)
- 13) Name the *useful* online teaching features from other lectures, which have not been applied in this course.
- 14) How do you experience the online teaching in this semester, in general? (Give the school grade)
- 15) How do you experience the online teaching in this semester, in the database course? (Give the school grade)
- 16) How do you value your personal learning progress during the online teaching in relation to the in-classroom teaching?
- 17) Do you frequently exchange your opinion concerning the course with your fellow students?
- 18) Exchange of opinions with fellow students during online teaching is (longer| shorter| equal) in relation to exchange of opinions during in-classroom teaching.
- 19) Name the most important thing which you miss during the online teaching in relation to the in-classroom teaching.
- 20) Name the online teaching features, which are advantageous in relation to the in-classroom lectures.
- 21) Name the online teaching features, which are disadvantageous in relation the in-classroom lectures.
- 22) Name the main advantages of the semester taught online in relation to the semester taught in-classroom.
- 23) Name the main disadvantages of the semester taught online in relation to the semester taught in-classroom.

5. SUMMARY AND FUTURE WORK

For the lecturer, teaching without seeing the students was extremely unsatisfied and unpleasant. One reason is that students' feedback (nodding one's head or any other expression on faces) was missing. In some situations, teaching felt like talking to a wall.

During the in-classroom lectures, we usually taught 45 minutes twice, and made the short break in between. This solution is almost impossible, when teaching online, because one cannot expect that students can stay attentive for such a time period. For this reason, all video streams concerning the lecturing had been streamlined to last between 20 and 25 minutes.

In future, there will be only slight changes to the existing methodology. The idea is to improve the concept and to change some issues, listed below:

- a) In online teaching, there is a discussion in progress, whether the lecturer should switch the video camera on or off. In this lecture, the camera has been activated only temporarily. From our point of view, the camera should be activated all the time, especially for freshman students. Therefore, this will be one of the changes for upcoming lectures.
- b) The move from Moodle to another, not so complex content management tool is planned, too. As already said, Moodle is too complex, and its use leads often to confusion.

6. REFERENCES

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